ENVIRONMENTAL MONITORING OF FOREST INSECT CONTROL OPERATIONS (EMOFICO)

1985 REPORT

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ABSTRACT

This multi-disciplinary compilation of 22 reports concerns primarily the environmental monitoring of the spruce budworm aerial spray operations in New Brunswick in 1985 with some information from other jurisdictions. The 29 authors report on the operational and regulatory aspects of the spray program, and on the insecticide ecology in ecosystems associated with spruce-fir forests which include studies on songbirds, freshwater fauna, toxicology, insecticide analysis, insecticide transport, persistence and contamination. The insecticides studied were fenitrothion, matacil, mexacarbate and Bacillus thuringiensis.

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FOREWORD

The New Brunswick Committee for Environmental Monitoring of Forest Insect Control Operations (ENOFICO) is an informal association of biologists, foresters, environmental specialists and chemists from federal and provincial governments, industry and universities. Its prime objective is to assess the impact of operational spray programs on non-target organisms and ecological processes in forest and adjacent ecosystems. By implication this includes experimental sprays and complementary laboratory studies. Efficacy is also considered, insofar as it relates to environmental effects. Potential consequences of forest spray programs for human health are beyond the Committee's terms of reference. Although the Committee's focus is on spray activities in New Brunswick, it seeks to keep aware of forest insect control operations and related environmental studies in the Atlantic region as well as in Quebec and Maine.

The Committee assumed its present name and structure in 1976, and has been under the aegis of the Department of Municipal Affairs and Environment (formerly the Department of the Environment) since 1980. The 1985 report, like its predecessors, is aimed at a broad readership - scientists, regulators, resource managers and, not the least important, the public. It consists essentially of preliminary reports and abstracts of reports completed.

For further information on the role of the New Brunswick Committee for ENOFICO as well as an instructive statement on insecticide ecology, the reader is referred to the Committee's combined 1978-1979 report.

Steering Committee

D. I. Besner (Department of Municipal Affairs and Environment)
D. C. Eidt (Canadian Forestry Service)
P. A. Pearce (Canadian Wildlife Service)
W. A. Sexsmith (Department of Municipal Affairs and Environment)

RECOMMENDATIONS

A consensus of the EMOFICO Committee:

It is recommended:

(1) that government agencies continue to support research and monitoring of the environmental effects of pesticides,

(2) that regulatory agencies continue to review the rationale for the specifications for buffer zones recognizing that much work has been done in the area of spray technology,

(3) that monitoring, research and regulatory agencies make a greater effort to explain to the public the significance of their findings,

(4) that the environmental implications of the use of Bacillus thuringiensis be clarified,

(5) that the environmental implications of the potential use of mexacarbate be reviewed,

(6) that monitoring and research agencies make a concerted effort to determine the routes and time frames for degradation of insecticides and adjuvants to innocuous products in various matrices,

(7) that further work be encouraged on the biological significance of pesticide residues in the forest environment, and

(8) that continued liaison with monitoring groups in other jurisdictions be encouraged.

OPERATIONAL SPRAYING

1985 SPRUCE BUDWORM PROTECTION PROGRAM IN NEW BRUNSWICK

N. CARTER

1985 Spray Program

The 1985 spruce budworm spray program conducted by Forest Protection Limited, in New Brunswick covered approximately 701,000 ha. (Figure 1). This represents a 32% reduction from 1984. Of the total area treated, about 85% was in the industrial part of the program (i.e. beyond 1.6 km from habitation) and the balance was in the non-industrial sector consisting of small private woodlots.

Chemical insecticides were used over 88% of the program and B.t. on the remainder. Aminocarb (Matacil 180 F) was sprayed over 452,000 ha; fenitrothion (Sumithion) over 168,000 ha; and B.t. was sprayed over 81,000 ha. Both chemicals were applied in water-based formulations and B.t. was applied undiluted (Table 1).

A total of 75 aircraft were involved in the program, 38 of which were spray planes, including 12 TBMs, 22 agricultural-type spray planes, and 4 helicopters (Bell 206s) (Table 2). TBMs were only used in the industrial part of the program and sprayed 66% of the total area treated.

Spray operations commenced on the evening of May 26 and terminated on June 26. The commencement date was the same as in 1984 and for the second consecutive year was later than normal due to cool spring weather. At the termination date, approximately 9,000 ha of B.t. spraying were left undone. These areas were in the southeastern portion of the province and were scheduled for treatment based on spruce timing. A combination of the late timing, poor spray weather, and presence of visible defoliation accounted for these areas not being sprayed.

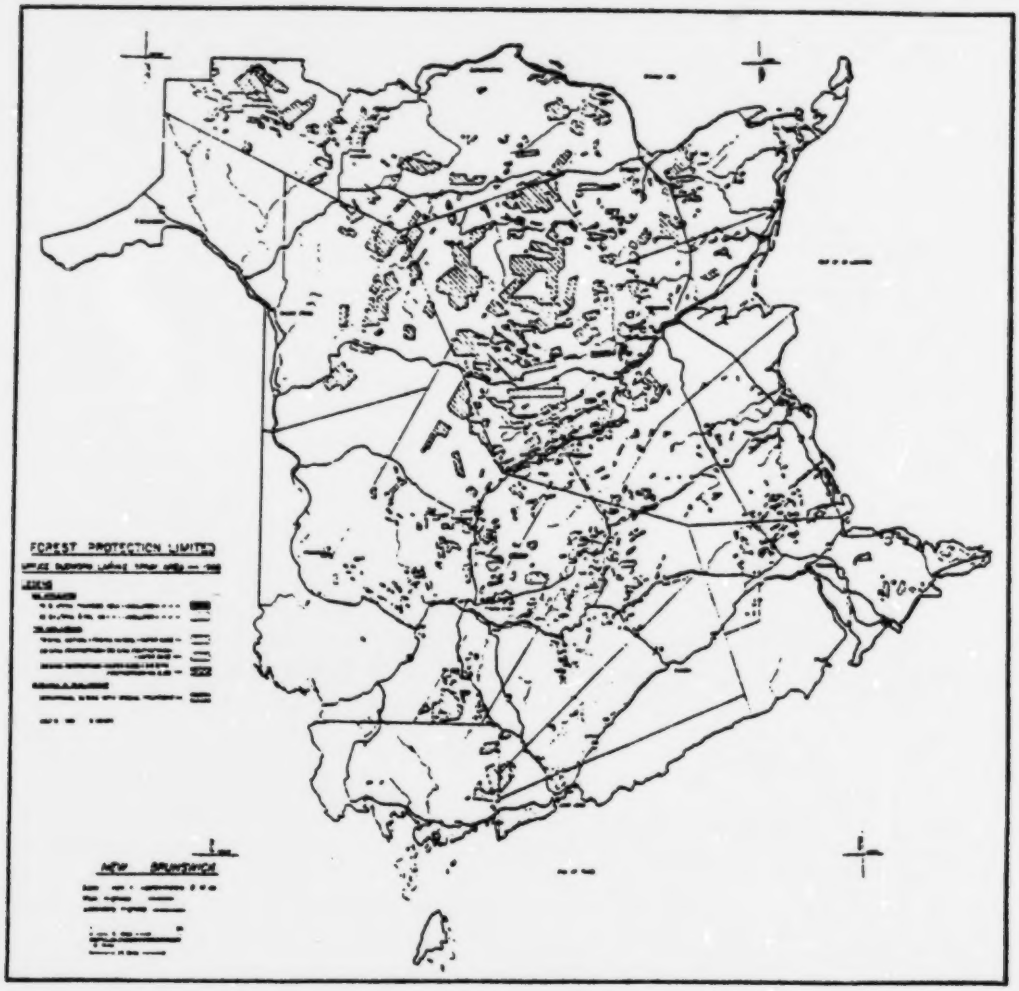

Figure 1. Distribution of spray blocks for the 1985 spruce budworm spray program in New Brunswick. (Detailed larger scale maps available at DFME).

Table 1. Areas Treated Operationally in the 1985 New Brunswick Spray Program*

Area Sprayed (ha and ac) By Insecticide, Application Rate, Formulation & Aircraft Type

Application	Hectares Thousands	Acres Thousands	Aircraft Type
One Application			
(a) 30 B.I.U./ha Dipel 132 Undiluted - 2.35 L/ha	78	192	TBM, M18, Ag Cat, Bell 206 Pawnee, Ag Truck
(b) 30 B.I.U./ha Thuricide 48LV Undiluted - 2.35 L/ha	3	8	M18
	81	200	
Two Applications			
(a) 210 g/ha Sumithion in 1.46 L/ha + 210 g/ha Sumithion in 1.46 L/ha - Dowanol, Atlox 3409F and water.	165	408	TBM, M18, Ag Truck, Pawnee, Ag Cat, Bell 206
(b) 210 g/ha Sumithion in 1.46 L/ha - Dowanol Atlox 3409F and water + 210 g/ha Sumithion in 1.46 L/ha Cyclosol 63 and Oil	3	8	TBM
(c) 70 g/ha Matacil 180F in 1.46 L/ha + 70 g/ha Matacil 180F in 1.46 L/ha Atlox 3409F and water.	447	1 105	TBM, Ag Cat
(d) 70 g/ha Matacil 180F + 70 g/ha Matacil 180F - Undiluted - 0.4 L/ha	5	11	Ag Truck
TOTAL	620	1 532	
GRAND TOTAL	701	1 732	

* Source - Irving, H.J. 1985. Forest Protection Limited 1985 Program Report

Table 2. Aircraft fleet used in the 1985 New Brunswick Spray Program*

Aircraft Type	FPL Owned FPL Operated FPL Controlled	Dry Leased FPL Operated FPL Controlled	Contracted FPL Controlled	Total
Spray Aircraft				
TBM Avenger	12	---	---	12
Ag-Cat	---	---	8	8
Cessna 188	2	---	6	8
M-18	---	---	4	4
Pawnee	---	---	2	2
Bell 206	---	---	4	4
Total Spray	14	---	24	38
NonSpray Aircraft				
Cessna 185	---	3	---	3
Cessna 172	---	28	---	28
Robinson 22	---	---	3	3
Bell 206 (Rescue)	---	---	1	1
Bell 47	---	---	2	2
Total NonSpray	---	31	6	37

38 Spray Aircraft + 37 NonSpray Aircraft = 75 Total

* Source: Irving, H.J. 1985. Forest Protection Limited 1985 Program Report

Results of Spray Program

At present, the objectives of the spray program in New Brunswick are to retain 60% or more of the current year's needles on balsam fir and 50% or more on red-black spruce. Virtually all the red-black spruce trees sampled met the foliage protection objectives regardless of treatment (Table 3). Results on balsam fir were also greatly successful though not to the same high degree.

During the aerial defoliation survey there were approximately 134,000 ha of moderate and severe defoliation detected within all spray areas (Table 4). This represented 12.5% of the total province-wide defoliation, or 19.1% of the total area treated by all insecticides. On a treatment basis, 15.0% of the aminocarb areas were defoliated, 28.8% of the fenitrothion areas were defoliated, and 21.8% of the B.t. areas were defoliated.

Spruce Budworm Conditions in 1985

The 1985 aerial defoliation survey was conducted in the standard manner and revealed an estimated 1.07 million ha of combined moderate and severe defoliation (Figure 2). Ground checks revealed that rain and wind prior to the survey had removed some evidence of defoliation making it impossible to distinguish light defoliation from the air, and likewise made it impossible to reliably distinguish between moderate and severe defoliation. Although defoliation was scattered throughout the province, the largest concentrations were in the northwest, central and southeast parts of the province. For the sake of comparison the total estimated area of defoliation for 1985 is about 50% higher than 1984 (0.73 million ha) and about 50% lower than for 1983 (2.03 million ha).

Forecast of Infestation for 1986

The traditional egg mass survey for predicting spruce budworm infestation levels in New Brunswick was replaced completely this year by the overwintering larval of L2 survey. A total of 1 521 L2 sample points have been processed. Comparing these sample results with last year's egg mass survey, there was a 15 percent decrease in the proportion of forecast points falling in the HIGH category (Table 5). This

Table 3. Number (and percent) of sampled trees meeting foliage protection objectives on balsam fir and red-black spruce in each treatment.

TREATMENT	BALSAM FIR	RED-BLACK SPRUCE
TBM		
2x Matacil	3021 (94)	2242 (92)
2x Fenitrothion	121 (79)	15 (100)
1x Dipel	60 (90)	6 (100)
SSP*		
2x Matacil	319 (91)	390 (100)
2x Fenitrothion	1375 (91)	683 (99)
1x Dipel	418 (75)	1055 (83)
1x Thuricide	30 (100)	12 (100)

SSP = Small Spray Planes

Table 4. Area (ha) defoliated within each treatment.

TREATMENT	AREA (ha) DEFOLIATED
TBM	
2x Matacil	64 985
2x Fenitrothion	17 563
1x B.t.	2 248
SUB-TOTAL	84 796
SSP*	
2x Matacil	2 925
2x Fenitrothion	30 845
1x B.t.	15 393
SUB-TOTAL	49 163
GRAND TOTAL	133 959

*SSP = Small Spray Planes

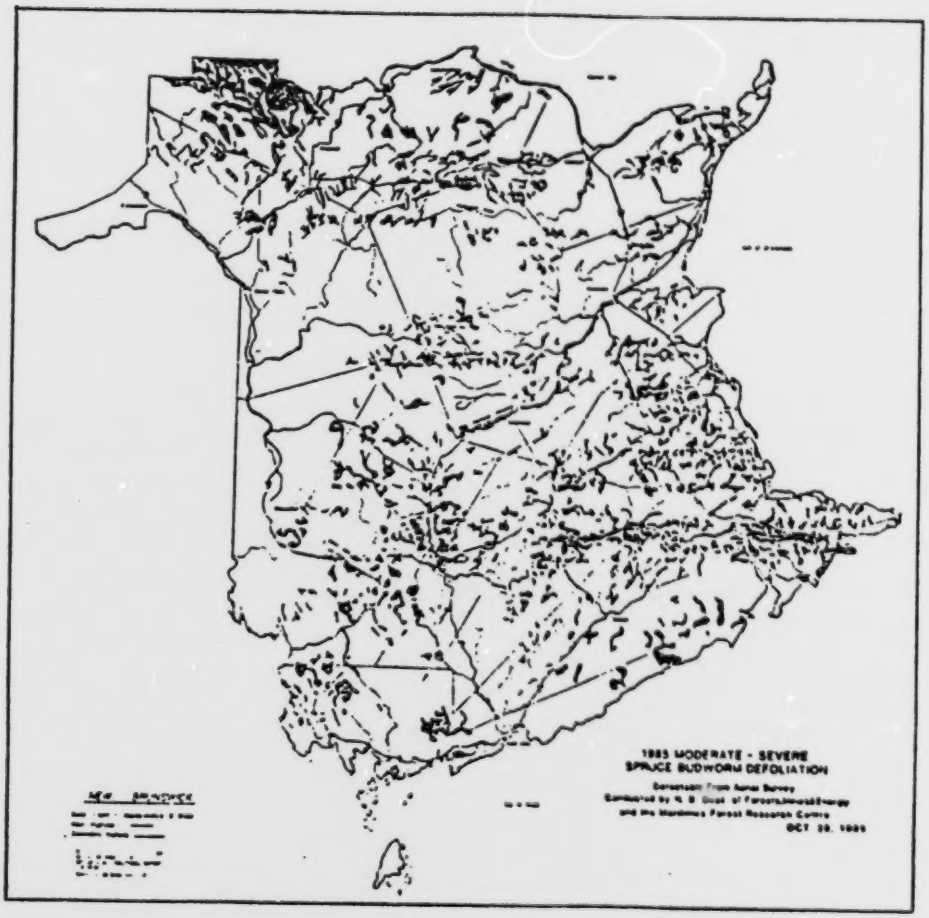

Figure 2. Distribution of moderate and severe spruce budworm defoliation in New Brunswick detected in the 1985 aerial defoliation survey.

Table 5. Comparison of 1985 Spruce Budworm L2-Survey Data With The 1981 to 1984 Egg-Mass Data.

	FORECAST INFESTATION LEVEL			
	LOW	MODERATE	HIGH	
1981 egg-mass	591 (34%)	441 (25%)	708 (41%)	n=1740
1982 egg-mass	458 (26%)	512 (29%)	783 (45%)	n=1753
1983 egg-mass	636 (48%)	257 (20%)	423 (32%)	n=1316
1984 egg-mass	747 (51%)	331 (22%)	398 (27%)	n=1476
1985 L2	833 (55%)	503 (33%)	185 (12%)	n=1521

Table 6. Comparison of size of moderate to high infestations forecasted from 1982 to 1985.

YEAR (n)	AREA FORECAST (n + 1)
1982	5.30 million ha
1983	4.10 million ha
1984	3.57 million ha
1985	3.15 million ha

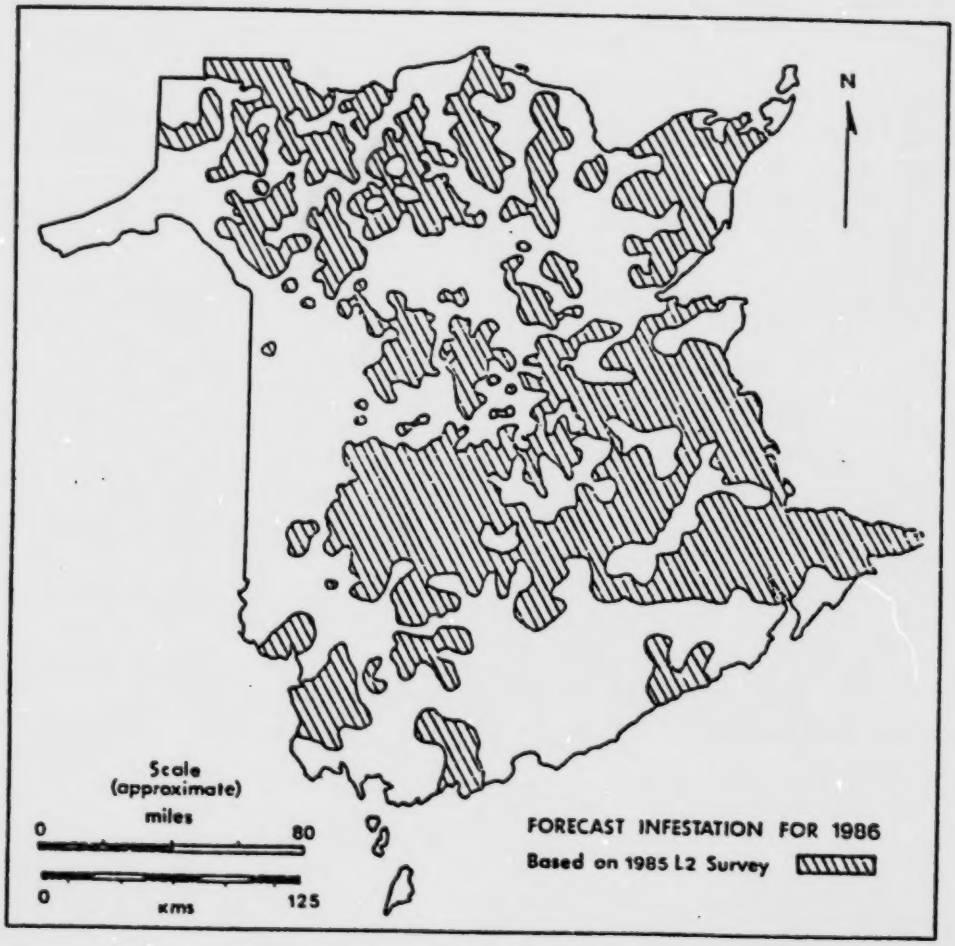

Figure 3. Moderate and severe spruce budworm infestation forecast for 1986 in New Brunswick (based on 1985 L2 survey).

has resulted in a 4 percent increase in the proportion of plots in the LOW and 11 percent increase in the MODERATE categories. In terms of overall distribution, however, MODERATE and HIGH populations are still present in large patches across the northern part of the province and in a large band across the south-central region into the southeast. Most of the western, north-central, and southern portions of the province are LOW. The total area forecast (Figure 3) to be moderately to severely infested in 1986 is approximately 3.15 million ha - a continuation of the decline over the past few years (Table 6).

Plans for 1986

Spray plans for 1986 have not been formulated at this time. It appears, however, that a protection program similar to the 1985 program will be required in New Brunswick in 1986. We anticipate that chemical insecticides will be used in the bulk of the industrial forest areas and B.t. within the 1.6 km set-back from habitation. Tentative spray plans will be known by mid-December.

YEAR TO YEAR RESPRAY IN NEW BRUNSWICK

D.C. Eidt and C.A.A. Weaver

The distribution and degree of overlap of spray blocks from year to year change because of the shifting patterns of hazard to trees posed by forest insects. It is important to know the history of respraying and the chances of future respraying because of the possibilities of persistent residues, environmental perturbations, and resistance in the target insect. Eidt and Fisher, C.F.S. Res. Notes 2:13-16, 1982, published estimates of chances of respray based on years up to 1978. We measured areas of overlap on spray maps to update the chances to 1985. Barring substantial changes in budworm infestation or spray strategy, we estimate the chances of any particular forested area in New Brunswick being sprayed two consecutive years at about 15% and three years in a row at about 6%. The odds on an area sprayed one year being sprayed again the next are higher, about 50%, and the next two years, about 11%. For further details see D.C. Eidt and C.A.A. Weaver 1986. Frequency to forest spraying

and use of B.t. in New Brunswick, 1975-1980. Canadian Forestry Service Information Report M-X-158.

THE EVOLUTION OF BUFFER ZONES IN NEW BRUNSWICK

W. A. Sexsmith

Introduction

Buffer zones or no-spray areas have become important regulatory tools in the spruce budworm spray program in New Brunswick. The following report outlines the evolution of buffer zone regulation in New Brunswick including the evolution of the regulatory role of the province, the types and definitions of areas given spray buffer protection , the buffer zones applied to each type of buffered situation, and the rationale behind buffer establishment in each situation.

The Evolution of the Provincial Regulatory Role

Although a Pesticides Control Act (PCA) under the New Brunswick Department of Agriculture was enacted in 1973 (Table 1), the formal mechanism for the authorization of insecticide use in forest insect control operations was established in 1974 under provisions of the Pest Control Products Act, administered by Agriculture Canada. The province was involved in the review and approval of the budworm spray programs via an interdisciplinary committee, but the permit to spray was signed by the district supervisor for Agriculture Canada in accordance with Agriculture Canada Memorandum T-104 requirements.

In 1976 , the PCA was amended, and , in 1977, Regulations for the Act were created. This resulted in the establishment of the Pesticides Advisory Board (PAB) consisting of provincial government representatives. Part of the responsibility of this Board is to review and grant budworm spray permits. It is within these permits that the conditions, such as buffer zones, under which spraying must take place, are issued. In this first year of its existence, both Agriculture Canada and the PAB, under

TABLE 1

EVOLUTION OF BUFFER ZONES - NEW BRUNSWICK

Evolution of legislation and provincial role in pesticides control

DATE	LEGISLATION	ROLE
1973	Pesticides Control Act- N.B.Agriculture	
1974		- province involved in review and approval of projects via inter-disciplinary committee - permit signed by district supervisor Ag Canada -T-104
1976	PCA-amended	
1977	Agriculture Regulations for PCA - Ag	- both Ag Canada and PAB/Ag signed permit
1978		- PAB/Ag
1979	PCA-amended Environment	- PAB/Ag
1980		- PAB/Env. - Minister signed permit
1981		- PAB/Env.
1982	PCA-amended Environment	- PAB/Env.
1983	Regulations for PCA-Env.	- PAB/Env.

the Department of Agriculture, reviewed and issued the permits to spray.

In 1978, permits were issued by the PAB only. The PCA was amended and became the responsibility of the Department of the Environment in 1979. However this occurred late in the year so that the PAB under the auspices of the Department of Agriculture issued the permits for the spray season. By 1980, the Department of Environment was fully ensconced as the regulatory agency for pesticide applications in the province. The PAB, operating under this Department, reviews permit applications, but it is the Minister who actually grants the permits, on PAB advisement. The PCA was amended in 1982, and new Regulations were created in 1983.

The PAB plays a very important role in the development of buffer zones . This interdisciplinary body, made up of representatives from provincial departments such as Municipal Affairs and Environment, Health and Community Services, Natural Resources and Energy, Agriculture, receives, solicits and assesses information pertaining to setbacks and other information pertinent to regulation of spraying of pesticides for spruce budworm control.

Buffer Zone Types and Definitions

In New Brunswick, there are eight types of areas (Table 2) that have or have had buffer zones over the years.

Habitation is defined as a dwelling or structure that has permanent human occupation. The setback is measured from the structure not the property boundary.

Lakes are bodies of water that are greater than 40 ha in size. Rivers that are of a significant size (roughly greater than 100 m wide) are considered major rivers. When the proposed spray areas

TABLE 2

EVOLUTION OF BUFFER ZONES - NEW BRUNSWICK

	1977*	1978	1979	1980
HABITATION	1.6 km	1.6 km	1.6 km	1.6 km
LAKES (> 40 ha)	400 m	400 m	400 m	
DESIGNATED MAJOR RIVERS	400 m	400 m	400 m	
OPEN WATER BODIES				
ECOLOGICAL RESERVES				400 m
MUNICIPAL WATER (point of extraction)	3.2 km	3.2 km	3.2 km	3.2km
BLUEBERRY FIELDS	3.2 km	3.2 km	3.2 km	3.2km
COAST			1.6 km	1.6 km

* - all formulations

are reviewed, these waters to be buffered are designated by the reviewing agency.

Open water bodies are considered to be waters that are visible to the pilot and/or the spotter pilot soon enough for the spray booms to be shut off.

Ecological reserves are areas of land that have been officially proclaimed as such and have been set aside in order to preserve samples of the New Brunswick ecosystem for present and future biological research (Anonymous 1985).

Municipal waters are municipal water reservoirs, impoundments, or other bodies of surface water from which drinking water is taken for municipalities. The setback is measured from the point where the water is extracted.

Blueberry fields are areas where blueberries are grown commercially.

Coast refers to the line where land meets the sea, Bay of Fundy, Northumberland Strait, etc.

Buffer Zones and their Rationale

Although aerial spraying for spruce budworm control has been going on in the province almost annually since 1952 (Varty 1976), buffer zones were not in use until 1977. During the sixties, what could perhaps be termed types of discretionary buffers were implemented from time to time (Irving 1986) such as booming off for water and avoidance of fish hatcheries. From 1963 to 1968, the enc of DDT spraying, phosphamidon, with low toxicity to fish, was used for safety zone spraying (152-300 m) along streams and rivers to minimize the effects to aquatic life (Prebble 1975).

In 1970, several blueberry growers, whose fields were located near fenitrothion-sprayed forests, reported unusually low pollinator activity and attributed their crop losses to the spray operation. As a result, in 1971, an interim injunction ordered Forest Protection Limited, the main agency responsible for the spray program, to conduct no spraying program against the spruce budworm within a two mile radius of blueberry fields (Bridges Bros. v. Forest

Protection Limited 1976). It was not possible at that time to document the extent of bee mortality or the implication of forest spraying, but the evidence was sufficient to stimulate more research and create a greater concern for pollinators in future spray programs. The resulting research showed evidence of bee mortality, and a no-spray zone of at least 3.2 km was recommended (Wood 1974). The interim injunction was dissolved in 1976 and was replaced by a declaratory order that did not mention specific distances (Bridges Brothers Ltd. v. Forest Protection Limited 1976). It was not possible at that time to document the extent of bee mortality or the implication of forest spraying, but the evidence was sufficent to stimulate more research and create a greater concern for pollinators in future spray programs. The resulting research showed evidence of bee mortality, and a no-spray zone of at least 3.2 km was recommended (Wood 1974). The interim injunction was dissolved in 1976 and was replaced by a declaratory order that did not mention specific distances (Bridges Brothers Ltd. v. Forest Protection Limited 1976). Although Forest Protection Limited has been mostly self-regulating over the years in the area of blueberry field setbacks, the buffer zones instituted by the PAB are 3.2 km (about 2 mi.) from blueberry fields for chemical formulations such as fenitrothion and aminocarb (Townsend 1982).

However, it was really, in the 1970's, when attention to human health risks was directed towards Reye's Syndrome with apparently high incidence rates reported in New Brunswick (Hatcher and White 1984) that the movement towards the use of buffer zones or no spray areas as regulatory tools began. It was hypothesized that the disease was related to the viral enhancing property of emulsifiers (Hatcher and White 1984). In 1976, a task force was struck to examine the possible association. Drift studies done in 1976 found spray deposit at least 1.6 km beyond block boundaries (Varty 1976, Spitzer 1984). The combined public pressure against the spray program and the drift study information resulted in a government decision to institute a 1.6 km setback from human habitation for the 1977 spray program (Table 2) for all formulations. In addition to the setback from habitation , a 3.2 km setback from municipal drinking water supplies (Table 2) was instituted in the same year, the theory being that

the extra 1.6 km would provide additional protection to the watersheds that drain into the drinking water supplies. This setback has remained unchanged through 1985.

In 1978, two new buffer zones were added (Table 2). Spray operators were required to avoid spraying within 400 m(the swath width of a 3-T.B.M. spray team) directly adjacent to, and surrounding, all bodies of water greater than 40 ha. These buffer zones were also applied to all major rivers. The rationale was that this would be the minimum size that could be sighted from the air while allowing reaction time on the part of the spray pilots. Field studies conducted in conjunction with the 1980 spray program indicated that a 400-m, no-spray "buffer zone" was sufficient to significantly reduce the incidental deposit of formulation (Ernst et al. 1980). Traces of fenitrothion, one of the pesticides used in the budworm spray program, were found in shellfish in 1976. Additional studies done in 1977 also showed residues to be present. Concerns about these findings were raised in the 1977 EMOFICO report (Varty 1978). As a result, a 1.6-km setback was required from coastal waters.

There were no additions or changes for 1979,and two in 1980 (Table 2). The 1.6 km coastal buffer zone was dropped, with the stipulation that spraying take place in blocks near the coast only when the wind was blowing from the coast. This change resulted from further studies regarding fenitrothion residues in shellfish, the conclusions being that although trace amounts of residues were found, fenitrothion will not accumulate to any appreciable extent in marine shellfish and that these residues are transient(Varty 1980).A 400-m setback was instituted for proclaimed ecological reserves (areas of New Brunswick reserved for ecological purposes). Proclaimed reserves have been in existence since 1976; however, it wasn't until 1980 that any fell within a spray block. It was thought that, as with the aquatic setback, 400-m would provide sufficient protection from any significant terrestrial impact.

Until 1981, the spruce budworm spray program in New Brunswick consisted of large blocks primarily sprayed by large aircraft (T.B.M.s). In 1980, the New Brunswick Department of Natural Resources became concerned about the deterioration of the forested

areas within the 1.6-km setback zones. In order to have a guaranteed wood supply for the future, these areas, many of which were privately owned forest land, had to be protected from budworm damage. Drift studies done in 1980 (Crabbe et al.) using smaller agricultural type aircraft showed that 300 m would provide an adequate buffer from human habitation, thus allowing a large portion of the forest within the 1.6-km setback to be protected. This 300 m buffer zone from human habitation (Table 3) for agricultural type aircraft was instituted for the 1981 spray program, along with a 65 m buffer for open water. This heralded the beginning of the two-part spray program for Forest Protection Limited with large blocks (woodland) being sprayed with large aircraft 1.6 km from habitation and 400 m from large lakes and rivers, and with small blocks (woodlots) being sprayed with small aircraft 300 m from habitation and 65 m from open water. The 65 m setback (the average swath width of an agricultural-type aircraft) was used as an aquatic setback for aerial spraying of agricultural crops, and was adopted as appropriate for woodlot spraying. Gordon (1982) found that the 65-m buffer zone from aquatic systems was adequate to reduce incidental contamination by forest herbicides.

In the spring of 1982, the First Report of the New Brunswick Task Force on the Environment and Reye's Syndrome (Spitzer 1982) made recommendations against the use of the emulsifier Atlox and against the use of solvents containing fractions of fossil fuel oil, such as Cyclosol 63. Since both Atlox and Cyclosol 63 were ingredients in the formulations planned for 1982, certain compromises were made for that year. It was decided that the oil formulations would be allowed but that a 3.2-km setback from habitation was required (Table 4). Water based formulations flown by agricultural aircraft had a 300 m setback from habitation and 65 m from open water as in the previous year. A 155-m setback from open water was required for the formulation of fenitrothion and Dowanol without water because of concerns about the effects of the large amount of solvent on aquatics. The setbacks for Bacillus thuringiensis (B.t.), sprayed operationally in 1982, were the same as the ones for the water-based formulations sprayed by small aircraft, except that the setback from blueberry fields, because B.t. is non-toxic to Hymenoptera, was eliminated.

TABLE 3

EVOLUTION OF BUFFER ZONES - NEW BRUNSWICK

1981*

	WOODLANDS**	WOODLOTS***
HABITATION	1.6 km	300 m
LAKES (> 40 ha)	400 m	
DESIGNATED MAJOR RIVERS	400 m	
OPEN WATER BODIES		65 m
ECOLOGICAL RESERVES	400 m	
MUNICIPAL WATER (point of extraction)	3.2 km	3.2 km
BLUEBERRY FIELDS	3.2 km	3.2 km

* - all formulations
** - large aircraft (T.B.M.s)
*** - small aircraft (agricultural)

TABLE 4

EVOLUTION OF BUFFER ZONES - NEW BRUNSWICK

1982

	WOODLANDS	WOODLOTS	
	oil*	H_2O	B.t.
HABITATION	3.2 km	300 m	300 m
LAKES (> 40 ha)	400 m		
DESIGNATED MAJOR RIVERS	400 m		
OPEN WATER BODIES		65 m**	65 m
ECOLOGICAL RESERVES	400 m		
MUNICIPAL WATER (point of extraction)	3.2 km	3.2 km	3.2 km
BLUEBERRY FIELDS	3.2 km	3.2 km	0

* - formulation
** - 155 m for fenitrothion and Dowanol

Consideration was given to a request by the Department of Natural Resources to reduce the habitation setback for B.t. in order to protect more of the private lands so vital to future wood supply needs. In 1983, the 300-m setback from habitation (Table 5) for B.t. was reduced to 155-m . This 155-m setback was adopted from the agricultural setback for insecticides.

A request by the Department of Natural Resources to reduce the 400-m setback around ecological reserves for the woodlot or small aircraft spray program was reviewed by the PAB. For the 1984 spray season, the decision was made to allow small aircraft to spray within 65 m of ecological reserves (Table 6) , using the rationale that 65 m would provide sufficient distance to reduce incidental contamination in a terrestrial situation as with an aquatic situation. In addition, Natural Resources requested that the 65 m buffer zone for open water be waived to allow the spraying of B.t. adjacent to watercourses. Work done by Eidt (1985) showed that B.t. as used in budworm spray operations posed no hazard to aquatic insects. Because of this information, the 65 m buffer zone for open water was reduced to 0 for the 1984 spray season (Table 6).

Summary

Buffer zones have become an integral part of the spruce budworm spray program in New Brunswick. These no-spray areas serve to reduce or eliminate the possible impact on specific parts of the environment. It is important to note here that these buffers also provide guidelines within which the applicators can work, giving them some protection from objection to spraying by individuals or groups. There have been no changes in the buffer zones since 1984. However, because of the dynamics of the spruce budworm spray program, as new information becomes available, and as new situations arise, the Pesticides Advisory Board is in place to review and assess and make recommendations appropriate to the data available.

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TABLE 5

EVOLUTION OF BUFFER ZONES - NEW BRUNSWICK

1983

	WOODLANDS		WOODLOTS	
	oil	H_2O	H_2O	B.T.
HABITATION	3.2 km	1.6 km	300 m	155 m
LAKES (> 40 ha)	400 m	400 m		
DESIGNATED MAJOR RIVERS	400 m	400 m		
OPEN WATER BODIES			65 m	65 m
ECOLOGICAL RESERVES	400 m	400 m		
MUNICIPAL WATER (point of extraction)	3.2 km	3.2 km	3.2 km	3.2km
BLUEBERRY FIELDS	3.2 km	3.2 km	3.2 km	0

TABLE 6

EVOLUTION OF BUFFER ZONES - NEW BRUNSWICK

1984 & 1985

	WOODLANDS H_2O	WOODLOTS H_2O	WOODLOTS B.t
HABITATION	1.6 km	300 m	155 m
LAKES (> 40 ha)	400 m		
DESIGNATED MAJOR RIVERS	400 m		
OPEN WATER BODIES		65 m	0
ECOLOGICAL RESERVES	400 m	65 m	65 m
MUNICIPAL WATER (point of extraction)	3.2 km	3.2 km	3.2 km
BLUEBERRY FIELDS	3.2 km	3.2 km	0

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EXPERIMENTAL SPRAYING

REVIEW OF RESEARCH AND DEVELOPMENT PROGRAM CONDUCTED IN NEW BRUNSWICK IN 1985 WITH VARIOUS INSECTICIDES, EQUIPMENT AND BIOLOGICAL CONTROL AGENTS

E. G. Kettela

INSECTICIDES

Bacillus thuringiensis:

Four sets of research and development trials with *B. t.* were conducted in New Brunswick in 1985. These trials included 1) semi-operational tests with Futura XLV at 2 dosage rates, 20 and 30 b.i.u./ha, 2) comparative tests wth Dipel 132 aqueous, Dipel 176 aqueous and Dipel 176 oil base all applied at 30 b.i.u.ha, 3) comparative tests with Thuricide 32 LV, 48 LV and 64 B as part of a three-year program to examine the relationship between deposit, concentration and efficacy, and 4) trials with Futura XLV, Dipel 176 and 132, Thuricide 64B and SAN-415 as possible control agents for *Zeiraphera* spp. infesting white spruce plantations. In the *Zeiraphera* trials efficacy on spruce budworm was determined as well.

In all cases these trials were conducted with small agricultural type aircraft such as Cessna 188's equipped with Micronaire AU 3000 atomizers. All the *B. t.*'s were applied undiluted.

The results indicate that Futura at 30 b.i.u./ha provides enhanced protection over 20 b.i.u./ha but that both results are acceptable. Dipel aqueous and oil base formulations at 30 b.i.u./ha provide similar and adequate results in terms of foliage protection. In the case of the Thuricide trials the 48 LV and 64 B products afforded better protection than the 32 LV product. The highest deposits were obtained with the 64 B. The results with the 48 LV and 64 B were similar suggesting an upper effective limit of *B. t.* concentration. Efficacy is clearly linked to deposit. Trials with most of the *B. t.*'s against *Zeiraphera* were inconclusive.

These were all cooperative studies involving support from the manufacturers, Forest Protection Limited, Maine, Quebec and the CFS.

Chemicals:

Three sets of research and development trials with chemicals were conducted in New Brunswick in 1985. One set of trials over 9 spray blocks tested Zectran (mexacarbate) as a possible control agent for Zeiraphera canadensis; the other two sets of trials were conducted against spruce budworm larvae.

These two sets of trials included 1) tests with fenitrothion to compare the standard formulation, an emulsion at 1.5 l/ha, against UULV applications of fenitrothion in solution with Dowanol TPM at a total volume of 0.4 l/ha and Sumithion 20F (a new product containing fenitrothion) at a reduced dosage of 140 g/ha in 1.5 l/ha, and 2) an operational evaluation of Matacil (aminocarb) 180F applied undiluted at a dosage of 70 g/ha in a volume of 0.4 l/ha. In addition, deposit of Matacil on foliage was compared to deposit on foliage in T.B.M. sprayed blocks. All test blocks were sprayed with Cessna 188 aircraft equipped with Micronaire AU 3000 nozzles.

The results indicate that against Zeiraphera Zectran, at all dosages tested, did not provide adequate protection. Tests against the spruce budworm indicate that:

1) fenitrothion as a UULV spray provides efficacy similar to that of the conventionally used emulsion and that Sumithion 20F at 140 g/ha appears to be a marginal dosage, but when similar deposit levels are compared it is as efficacious as either of the other fenitrothion formulations examined; and

2) Matacil 180F applied undiluted through Micronaire nozzles provided excellent foliage protection and corroborated the findings in 1984. Further deposit levels, expressed as ppm's of aminocarb were similar in both the UULV blocks and in operational blocks treated with T.B.M.'s.

EQUIPMENT

In an endeavour to develop ways to provide maximum protection to high value forest stands, Forest Protection Limited supported and participated in a study with CFS-Maritimes, R.P.C. and the Chemical Engineering Dept. of U.N.B. to evaluate spraying with helicopters equipped with Beecomist atomizers. Beecomist atomizers produce spray droplet spectra (with solutions) that approach the theoretical maximum for enhanced foliage impingement. Two areas were treated with a fenitrothion simulant, with the helicopter flying at 40 kph, the other at 120 kph. Results of chemical analysis indicate fairly high and uniform deposit throughout the crowns of trees and what appears to be, at first analysis, enhanced deposition.

Is this real, and does it mean enhanced efficacy?

BIOLOGICAL CONTROL AGENTS

In 1984 an inundative release of Trichogramma minutum (an insect egg paraasitoid) was carried out against Zeiraphera. Some 20×10^6 T. minutum were released on a 1 ha block. Results were encouraging and set the stage for further testing in 1985.

Sufficient T. minutum were obtained from the University of Guelph to carry out releases against both spruce budworm and Zeiraphera. With respect to budworm, 3 high value areas were treated, 2 young spaced forest stands, and a hedge. The results were very encouraging and parasitism of spruce budworm eggs was increased dramatically.

A 0.5-ha area of white spruce plantation in northern New Brunswick infested with Zeiraphera was also treated (at a release rate of 10×10^6 T. minutum/ha). Results show enhanced parasitism by T. minutum at about the same rate as in 1984. These tests indicate that T. minutum can be used to successfully elevate parasitism of pest eggs but it has yet to be demonstrated that this level of parasitism will effect a significant reduction in the next generation. Further tests are planned for 1986. T. minutum is not commercially available in Canada, and it is important to use select strains of T. minutum.

RESIDUES

PERSISTENCE OF FENITROTHION IN BALSAM FIR LEAF LITTER

D. C. Eidt, V. N. Mallet, C. A. A. Weaver

On July 9, 1984, 19 bags containing 30 g each of balsam fir foliage were placed on the forest floor in the U.N.B. woodlot. This foliage had been collected in a heavily sprayed area several weeks after spray so that the surface deposit would have been lost. The entire sample was thoroughly mixed and the concentration of fenitrothion in the foliage was determined to be 0.32 ug/g. The means for two lots of foliage collected on five dates in 1984 were reported in the 1984 EMOFICO Report. Further samples were collected until October 1985, when the last bag was taken.

Results were:

Date	Lapsed days	Concentrations (ug/g fresh weight
9 July 84	0	0.24, 0.40
13 July 84	4	0.22, 0.22
16 July 84	7	0.21, 0.38
23 July 84	14	0.32, 0.28
6 Aug. 84	28	0.35, 0.31
27 Aug. 84	49	0.29, 0.17
15 Oct. 84	98	0.36, 0.47
22 Apr. 85	287	0.33, 0.42
21 June 85	347	0.55, 0.83
26 Aug. 85	413	0.44, 0.40
16 Oct. 85	464	0.47

We cannot recognize any loss of fenitrothion over the 15 months exposure. The apparent increase in concentration was probably due to loss of other compounds, possibly water, because we did not determine moisture content.

Our original hypothesis was that the fenitrothion would be lost within a season, therefore we did not use enough bags to continue the experiment. To begin a new field experiment would put us back two years. It is questionable if it would be worthwhile to pursue the subject further because released fenitrothion would be attacked and decomposed very quickly by microorganisms. Using respiration as the criterion, Salonius (J. econ. Ent. 65-1089- 1090, 1972) found a massive dose of fenitrothion did not affect the decomposition process in forest soil.

OPERATIONAL DRIFT MONITORING WITH AN AIRCRAFT-MOUNTED SAMPLER

C. M. Riley and C. J. Weisner

A high volume sampler was designed and constructed to operate isokinetically when mounted on a Cessna 182. The Cessna flew a series of one kilometre sampling runs downwind of TBM teams spraying Matacil. Gas chromatographic analysis of the samples provided a time series of mean drift concentrations in the sampling region (2-3 km downwind of block). Drift concentrations varied from undetectable to 4.2 ug/m^3 and agreed well with results of previous experimental drift studies.

STUDIES ON THE ENVIRONMENTAL CHEMISTRY OF FORESTRY INSECTICIDES USED IN FPMI 1985 RESEARCH TRIALS

K. M. S. Sundaram, C. Feng, R. Nott and J. Broks

Introduction

This report describes the environmental chemistry and fate of three forestry chemicals, viz., aminocarb, fenitrothion and mexacarbate used during 1985

research programs in New Brunswick, Newfoundland and Ontario.

1. Canopy interception, deposition and fate of mexacarbate in a New Brunswick forest ecosystem

Mexacarbate insecticide residues and some of its common metabolites were evaluated in an aquatic field system in New Brunswick forest aerially sprayed with 70 g AI/ha twice at an interval of five days. Deposits and droplet spectra were recorded at various canopy depths, on ground cover and in open forest floor to determine patterns of foliar interception, and ground deposition, and if correlations existed among foliar concentrations, droplet densities and size spectra. Concentrations of the insecticide in stream and pond waters, sediment, aquatic plants and animals were measured at intervals of time. Residues in stream and pond waters peaked respectively at 0.73 ppb and 18.74 ppb and decreased rapidly below the detection limit (0.02 ppb) with 24h. Concentrations in some aquatic plants (slender spikerush, manna grass,etc.) were higher (ca. 500 ppb), persisted up to two days but decreased rapidly. Sediment, fish (caged and wild), tadpoles, aquatic insects, moss, and green algae did not accumulate detectable amounts of mexacarbate. Data indicate that mexacarbate at the dosage used will not accumulate to sufficient extent in the aquatic forest environments to pose any noticeable hazard to nontarget organisms. Demethylated (mono) N-methylcarbamate and dimethylaminoxylenol were detectable by thin-layer chromatography in some of the substrates studied but they also degraded rapidly.

2. Distribution and depositon of fenitrothion aerially applied to a boreal forest area near Searchmont, Ontario

In collaboration with the Environmental Impact group at the Institute, the distribution and deposition of the insecticide fenitrothion on nontarget biota was investigated to study the interactions between them if possible, to quantify the potential vulnerability and stress arising from pesticide exposure. The fenitrothion effects on biota following spraying could be direct as well as indirect and the magnitude and duration of these effects depend upon the chemical sprayed, dosage, organism exposure, susceptibility and biotope.

Samples of foliage (balsam fir and white birch) at different vertical and horizontal canopy position, different types of wild flowers, a variety of wild and caged bees, and water (inside and outside the spray blocks) were collected one day prior to and 1h following the insecticide application at 280 g AI/ha. Water samples were collected up to one day post-spray. Simulated foliar and floral samples and collection units containing Kromekote cards/glass plates were placed throughout the spray blocks to compare the deposition levels and droplet spectra of fenitrothion sprays on the targets. Insecticide residues in the extracts of samples (natural and simulated) were determined as well as the deposit levels on glass plates and droplet spectra on Kromekote cards. Deposits on the simulated samplers (fir needle and birch foliage made from aluminum wire and aluminum sheet respectively) and foliar concentrations in balsam fir decreased from top to bottom and laterally from outside to towards the tree trunk. Whereas such patterns were not observed in birch probably due to poor trapping of spray droplets. Regression analysis showed an approximately linear relationship between the deposits on the two (artificial and natural) fir surfaces. Similar correlations were also found on foliar (artificial) to ground deposits. Correlations were good between deposits found on different types of simulated and natural flowers but the amounts varied according to the geometry of the flowers under consideration.

Fenitrothion residue was detected (31 ppb) in stream water immediately after its aerial application and it dissipated very rapidly within the first 24h after the spray. The rapid dissipation of the chemical was due to dilution, degradation and possibly adsorption to other matrixes.

Fenitrothion-nontarget biota interactions are quite complex, requiring detailed analysis and critical interpretations using the residue levels found in various substrates. The field biologists are currently evaluating the primary (toxicological) and secondary (ecosystem changes) effects on nontarget biota arising from fenitrothion spray application over a boreal forest.

3. Post-spray residue concentrations of aminocarb and fenitrothion in balsam fir foliage at the mid-canopy level and deposit levels of the chemicals measured from glass plate rinses on the forest floor during the 1985 hemlock looper control program in Newfoundland.

The mid-crown foliar samples (1984 and 1985 growths) and the glass plates kept on the forest floor to receive the spray deposits were collected from the spray blocks and were extracted, concentrated, partitioned, cleaned-up using column adsorption chromatography, N-evaporated and analysed by GLC. The results are given in Tables 1 and 2. Plots 7, 9 and 15 were sprayed with Matacil - 180F (aminocarb) at 90, 135 and 185 g AI/ha respectively using a water-based formulation. Plots 12 and 13 were sprayed with fenitrothion flowable (FF) with a polymeric additive at 140 and 210 g AI/ha respectively. Plot 17 was sprayed with the conventional fenitrothion emulsion formulation (FE) at 210 g AI/ha.

From the data the following points emerge:

Table 1 (aminocarb)

1. Mean deposits of aminocarb on the forest floor increased with dosage. The increase appeared to be nonlinear. On average about 8% of the sprayed material reached the forest floor.

2. Similar trends were found between foliar concentrations and dosage, but the correlation seemed to be linear.

3. Needles of the 1985 growth appeared to be better collectors compared to the needles of 1984 growth. Needle exposure, geometry, needle size, terpene content, etc. could have had some role in the collection and retention of the material.

4. Correlations among dosage, foliar concentration and mortality of insects shoud be explored.

Table 2 (fenitrothion)

1. Mean deposits on the forest floor were unusually

TABLE 1

Aminocarb residues in balsam fir foliage following experimental application of the insecticide as an emulsion formulation at three different dosages during the 1985 hemock looper control program in Newfoundland

Plot	Dosage (g/ha)	Sample Sites in the sprayline used for composite sample preparation (m)	Deposit on glass plates (g/ha)	Mean deposit on glass plates (g/ha)	Aminocarb concn. (ppm) in foliage (fresh wt.)+ Needles of 1984 growth	Mean of the needles from 1984 growth (± SD)	Needles of 1985 growth	Mean of the needles from 1985 growth (± SD)
7	90	0,30,60	--*		0.55		0.57	
		90,120,150	7.21	7.73±0.90	0.50	0.55±0.05	0.45	0.64±0.19
		180,210,240	7.21		0.55		0.64	
		270,300	8.77		0.61		0.90	
8	135	0,30,60	2.21		0.49		0.24	
		90,120,150	6.99	8.74±5.16	0.63	0.80±0.28	0.28	1.07±0.94
		180,210,240	12.90		1.07		1.78	
		270,300	12.85		1.01		1.98	
15	180	0,30,60	21.87		1.53		1.74	
		90,120,150	16.18	15.32±7.02	0.80	1.22±0.31	1.48	1.99±1.05
		180,210,240	--*		1.31		3.53	
		270,300	7.91		1.24		1.20	

*Samples were lost in transit.
+Triplicate measurements.

TABLE 2
Fenitrothion residues in balsam fir foliage following experimental application of the insecticide as flowable and emulsion formulations during the 1985 hemlock looper control program in Newfoundland

Plot	Formulation and dosage	Sample sites in the sprayline used for composite sample preparation (m)	Deposit on glass plates (g/ha)	Mean deposit on glass plates (g/ha) (± SD)	Fenitrothion concn.(ppm)in foliage(fresh wt.)+ Needles of 1984 growth	Mean of the needles from 1984 growth (± SD)	Needles of 1985 growth	Mean of the needles from 1985 growth (± SD)
12	Fenitro	0,30,60	25.10		5.08		9.25	
	thion F	90,120,150	22.13	22.13±2.98	5.42	5.09±1.22	10.89	9.24±2.02
	140 g/ha	180,210,240	--*		3.46		6.40	
		270,300	19.15		6.40		10.42	
13	Fenitro	0,30,60	43.83		10.05		14.08	
	thion F	90,120,150	31.67	37.77±6.08	5.40	7.72±1.98	11.01	12.54±1.77
	210 g/ha	180,210,240	--*		8.39		14.06	
		270,300	37.82		7.04		11.01	
17	Fenitro	0,30,60	6.71		1.37		1.37	
	thion Emul.	90,120,150	4.08		0.46		0.84	
	210 g/ha	180,210,240	5.86	7.47±3.98	1.07	1.06±0.42	1.47	1.47±0.56
		270,300	13.21		1.34		2.20	

*Samples were lost in transit.
+Triplicate measurements.

high for fenitrothion F compared to aminocarb at equal dosages (plot 12 vs. plot 8). Deposit levels for fenitrothion F on the forest floor increased with dosage (plots 12 and 13). Higher deposit levels could possibly be due to polymeric additives in the formulation (FF). Such formulations also would give large NMD and VMD and the role of viscosity in deposition should be considered. The emulsion formulation (FE) gave poor ground deposition (3.6%) possibly due to volatilization of the adjuvant and accompanying codistillation of the AI.

2. Similarly very high deposition on the needles was observed for FF and it increased with dosage. Such a phenomenon has never been encountered before either with the same or with other formulations. As expected, the emulsion formulation gave poor deposition on the needles compared at the same dosage level (Plot 17 vs Plot 13). Physicochemical properties in addition to other factors could have played a key role in the depositon of AI on conifer needles.

3. Needles of the 1985 growth acted as better receptors to the spray cloud compared to the mature needles of 1984. Geometry of the growing branch tip, exposure to spray cloud and chemical content of the new foliage would have played some part. Additional research is necessary to be more definitive.

4. Correlations among dosage, formulation properties (role of adjuvants, viscosity, vapour pressure, surface tension, etc), foliar concentration and insect mortality should be explored and documented.

TERRESTRIAL IMPACTS

THE EFFECTS OF ZECTRAN (mexacarbate) ON SONGBIRDS

D. G. Busby, P. A. Pearce and N. R. Garrity

Perspective

The carbamate insecticide Zectran UCZF-19 is currently being evaluated for registration against the spruce budworm. Should it become registered for that purpose there is considerable potential for the product to become widely used. One of the primary

concerns remaining is its high acute toxicity to birds, especially songbirds occupying the forest canopy which is also prime habitat of the target insect.

During the past two field seasons the Canadian Wildlife Service, Atlantic Region, Toxic Chemicals Project, has devoted considerable time to evaluation of the impact of Zectran on songbirds. The insecticide is, like other carbamates and organophosphates, a cholinesterase (ChE) inhibitor. In 1984, a joint study by the Forest Pest Management Institute and the Canadian Wildlife Service determined that the effect of Zectran on brain ChE activity in adult songbirds was minimal and that the margin of safety was at least twofold the probable eventual operational dosage rate of 70 g AI (active ingredient)/ha. In the present study, the impact of Zectran on nestling songbirds was investigated. Additionally, the effects on songbirds of experimental high-dose application of Zectran to control spruce budmoth in plantations are reported.

The impact of experimental aerial application of Zectran on the growth and development of White-throated Sparrow nestlings.

Considerable overlap exists between the timing of spruce budworm spraying operations and the period of nestling rearing by songbirds. Although Zectran appears to be relatively safe to adult songbirds, there is some concern for the safety of nestlings. Concern lies primarily in the high acute toxicity of mexacarbate (active ingredient of Zectran) to birds

and the low levels of ChE activity found in young nestlings. The assumption is that nestlings, having only minimal ChE activity to carry out whatever nervous functions would be required at that age, would be less able to tolerate any ChE inhibition. Any mortality of nestlings could theoretically impact on future population levels, the ultimate parameter of greatest importance.

In the present study we investigated the effects of an experimental aerial application of Zectran on the growth and development of White-throated Sparrow nestlings. We consider the White-throated Sparrow to be a good representative songbird which we can use as a model for impact assessment. The insecticide was formulated in Triton X 114 (emulsifier) and water (carrier) and applied by Cessna aircraft at a rate of 70 g AI/ha, the probable eventual operational dosage. The insecticide was applied twice, 5 days apart, according to usual budworm spraying strategy. The study technique involved location of breeding pairs within the spray block boundaries and in a nearby untreated control area. Each pair was monitored throughout the nest building and egg laying periods. Upon hatching of the first egg, each nest was visited at about the same time each day. At each visit several measurements of nestling growth were taken; they were weight, tarsus length, wing length and 9th primary length. We had hoped to arrange the spray timing such that the maximum number of nestlings were exposed to both sprays - a worst case scenario. Unfortunately, due to poor weather and mechanical problems, spraying was delayed and only two nestlings from one nest fell into that category.

The effect of Zectran on nestling growth was examined in two ways. First, the growth data for exposed nestlings were subjected to a daily comparison with control data, for all four parameters. Second, the growth rates of both groups of nestlings were calculated and compared using regression analyses.

Neither method of data analysis gave any indication that growth of exposed birds was significantly different from controls. Further, visual examination of the data did not uncover any sources of possible statistically non-significant differences. The only possible effect of the spray involved direct observation of three nestlings, a few hours after the first spray, that appeared to be lethargic and

non-responsive to being handled. The next day, however, they behaved normally and their growth was not affected.

The response of free-living White-throated Sparrow nestlings to experimental dosing of Zectran.

The present study was conducted to gather further information on the effects of Zectran on nestling White-throated Sparrows. This type of study has several advantages over others utilizing aerial application as the method of exposing nestlings to the insecticide. 1) a location can be chosen to provide optimum availability of subject specimens so that statistically valid sample sizes can be obtained; 2) a spray block can only be treated as one unit, no matter what different stages of the nestling cycle the individual birds within the block may be at when the spray is applied. With dosing studies, treatment can be attuned to specific age groups, a parameter we now know to be relevant to nestling sensitivity; 3) exposure can be accurately controlled and quantified. Spray applications invariably leave many unanswered questions with regards to weather, evenness of spray, actual deposit, calibrations, etc.

It is recognized, however, that oral dosing is not a replacement but rather a supplement to aerial application studies. Some types of information we can obtain from dosing studies are 1) a relative acute oral toxicity of different budworm insecticides to free-living birds, whether adults or nestlings; 2) the relative sensitivity of different aged nestlings or adults to various insecticides; and 3) the effects of pure versus formulated insecticides on birds.

The dosing technique involved weighing of nestlings and, based on that weight, injecting an amount of Zectran, measured by microsyringe, into a common food item of the birds which was force-fed to the nestling. Several dosing regimes were followed. The results have not yet been analysed but some general statements can be made at this time. Single oral doses (based on the active ingredient, mexacarbate) as low as 5 mg/kg are lethal to young nestlings. Results from single oral doses at the 2.5 mg/kg rate are inconclusive. Administration of 1 mg/kg in single oral doses had no effect on growth. The 5 mg/kg and 2.5 mg/kg doses, when administered in three

equal quantities on three consective days, did not appear to affect survival or growth.

Two assumptions were then made; that the maximum likely residue level of Zectran in the food supply of songbirds after aerial application would be 2.5 mg/kg and the maximum likely duration of Zectran residues in the food supply would be 2 days. Both assumptions are without substantiation from field data but seem reasonable given what is known about the insecticide. Selected nests were then visited every second hour of the daylight period for two days and fed food items containing Zectran at levels equating to a diet concentration of 2.5 mg/kg. This scenario approximately simulates the frequency of feeding of nestlings by adult birds. Preliminary results of this experiment indicate that there was little or no effect of the insecticide on nestling survival or growth and development.

The effects on songbirds of experimental high-dose application of Zectran UCZF-19 to control spruce budmoth in plantations in northern New Brunswick.

An experimental spray program using Zectran UCZF-19 at dosages of 150 and 300 g AI/ha to treat an outbreak of Zeiraphera canadensis in white spruce plantations in northwestern New Brunswick provided the opportunity for the Canadian Wildlife Service to study the impact of high-dosage spraying on songbirds. Spray operations were carried out by Forest Patrol Ltd. under the supervision of the Canadian Forestry Service. The spraying was done using a Bell Jet Ranger 206 helicopter equipped with boom and nozzle hardware and a Sorenson spray tank. An emulsion consisting of Zectran (active ingredient mexacarbate), Triton x 114 (emulsifier), and water (carrier) was emitted at a dosage of 150 AI/ha in two back-to-back applications on one block and 150 g AI/ha on a second.

The impact of the spray program was assessed using a modified songbird census survey in which all birds seen or heard within a 50 m radius of fixed stops located every 100 m along walked routes were recorded. The starting time and sequence of the surveys, as well as the observer, remained constant throughout the study. Four census routes were established and conducted on four days pre-spray and four days post-spray. Routes 1 and 2 were in the 150

g AI/ha block, route 3 was in the 300 g AI/ha block and route 4 was the control route. To determine if smaller birds were more susceptible to spraying the population was divided into group 1, consisting of kinglets and warblers, and group 2, consisting of all other birds. Census data were subjected to a three factor analysis of a variance test.

No significant differences occurred between the pre- and post-spray numbers in group 2, the larger birds, on either route 1, route 2 or route 3. Similarily, no significant differences were noted between the pre- and post-spray numbers in group 1, the smaller birds, on route 1 and route 3. However, there was a significant decline in numbers of group 1 birds on the post-spray counts on route 2. The two most likely causes of such a decline are spring migration and insecticide effects. Migration has been a problem in similar studies and may result in an influx of warblers prior to spray application, many of which may depart shortly before or after the application, giving the impression of a toxic effect. The drop in post-spray numbers of several warbler species on route 2 can be attributed to migration. The possibility of a toxic effect on the Magnolia Warbler population cannot be ruled out, although the decrease was observed on the low-dose block suggesting a non spray-related cause.

SUMMARY

To date, studies by the Canadian Wildlife Service indicate that Zectran will not pose a serious hazard to songbirds should it become registered for use against spruce budworm. The margin of safety is broad: at least twice the intended eventual operational dosage appears to be essentially non-impactive, a situation not realized with the use of the organophosphate insecticide fenitrothion. Clearly, from the standpoint of hazard to songbirds, Zectran and another carbamate insecticide, Matacil (active ingredient aminocarb) are preferable to fenitrothion as currently used for spruce budworm control.

TOXICITY OF FENITROTHION TO ARTHROPODS IN PITCHER PLANTS

D. C. Eidt, W. L. Fairchild, and C. A. A. Weaver

Pitcher plants grow in bogs in close proximity to sprayed forests where they may directly receive fenitrothion. Fifteen pitcher plant leaves contained an average of 20 ml of fluid and had a opening of about 6 cm^2 which would theoretically result in 63 ug of fenitrothion per litre of fluid under a spray of 210 g/ha. Considering the usual 70 to 80% loss between spray aircraft and the ground, and the screening effect of the hood and surrounding vegetation, a concentration of less than 15 ug/L would be expected.

The fluid in ten pitchers was treated with each of four rates of fenitrothion in aqueous formulation using Dowanol TPM and Atlox on 29 July 1985. The average concentrations in the pitchers were 6.60, 3.31, 1.65 and 0.83 ug AI/L. Because of the different amounts of water in the pitchers, treatments actually ranged from an estimated 9.45 ug/L down to 0.31 ug/L.

Contained arthropods were removed, identified, and determined to be living, moribund, or dead. The pitcher plant mosquito Wyeomyia smithii and the midge Metriocnemus knabi were present in most pitchers. There was kill and intoxication of mosquito and midge larvae and pupae at both the 6.60 and 3.31 ug/L rates but not at the two lower rates or in the controls. Some larvae and pupae survived in all treatments. Mites and rotifers found in most pitchers were apparently not affected.

On the basis of these results, a hazard to pitcher plant mosquitos and midges is inferred. Although both species are beneficial to the plant, neither is essential.

THE BIOLOGICAL CONSEQUENCES OF LINGERING FENITROTHION RESIDUES IN CONIFER FOLIAGE - A SYNTHESIS

D. C. EIDT AND P. A. PEARCE

ABSTRACT*

Conifer foliage is a sink for fenitrothion, with a limited capacity for accumulation. Fenitrothion, not derivatives or metabolites, is retained from year to year and for at least one year in foliage in forest litter. Translocation can occur but has not been demonstrated to new foliage from foliage of the previous year.

Among forest animals, only insects have been identified as confined entirely to a diet of conifer needles. Diprionid sawflies, among those tested and observed, have been determined to be most sensitive to fenitrothion poisoning. Diprionids and conifer-feeding pamphiliid sawflies are most threatened because most eat old foliage and, in New Brunswick, may have to feed on contaminated foliage even in years when spraying does not occur.
Vertebrates that feed extensively on conifer foliage (none does exclusively) are deer, moose, snowshoe hares, and spruce grouse: spruce grouse is probably the most sensitive to fenitrothion. It is estimated that a 550-g grouse would have to eat 29 kg of foliage containing 1 ppm fenitrothion to ingest a dose lethal to 50% of a test population and that significant sublethal effects are unlikely.

*From a manuscript accepted for the August 1986 issue of Forest Chronicle.

AQUATIC IMPACTS

PRELIMINARY REPORT ON STUDIES OF THE IMPACT OF FORESTRY PESTICIDES ON AQUATIC FAUNA

W. Ernst

BIOASSAY STUDIES - FENITROTHION FLOWABLE FORMULATIONS

A series of bioassays was undertaken to compare the aquatic toxicity of the new fenitrothion flowable formulations with that of the presently used fenitrothion soluble formulations. Acute (96 h and 48 h) toxicity tests were conducted using threespine stickleback (*Gasterosteus aculeatus*), rainbow trout (*Salmo gairdneri*), water flea (*Daphnia magna*), blue mussel (*Mytilis edulis*), and the freshwater clam (*Anodonta spp.*) as test organisms. The results of these studies (Table 1) indicate that, with the exception of the freshwater clam, the new flowable product is not appreciably less toxic to aquatic organisms than is the older oil-soluble product. This is in contrast to the observations for previously tested aminocarb formulations, in which it was determined that the flowable formulation was much less toxic to aquatic organisms than the soluble formulations. In the case of the fresh water clam, the older fenitrothion formulation was approximately 4 times more toxic than the new formulations.

Since the fenitrothion flowable formulation consists of a suspension of fine particles of active ingredient, a bioconcentration test was conducted using a test organism whose feeding mechanism is to selectively concentrate fine particles. Blue mussels were exposed to fenitrothion flowable solutions (0.10 and 0.60 ug/L measured AI concentration) for 30 days and depurated in clean water for 30 days. Fenitrothion concentrations in the mussel tissues (Table 2) became elevated within 1 day of exposure but did not increase appreciably after that time. Bioconcentation factors (concentration in tissue wet weight/concentration in water) ranged from 15-20 in the low exposures and 15-40 in the high exposures. This is approximately the same as bioconcentation factors (30) noted previously for mussels exposed to

TABLE 1 ACUTE TOXICITY OF FENITROTHION FLOWABLE AND FENITROTHION SOLUBLE FORMULATIONS TO AQUATIC ORGANISMS

TEST	TEST DURATION (hours)	LC 50[a] FENITROTHION FLOWABLE FORMULATION[b]	LC 50[a] FENITROTHION SOLUBLE FORMULATION[c]
Daphnia magna	48	10.3 ppb	7.6 ppb
Threespine Stickleback	96	3.1 ppm	3.1 ppm
Rainbow Trout	96[d]	2.2 ppm	1.7 ppm
Blue Mussel	96[d]	1.5 ppm	18.8 ppm
Freshwater Clam	96[d]	29.0, 25.0 ppm	8.1, 5.2 ppm

(a) LC 50's calculated using nominal fenitrothion (ai) concentration.

(b) Fenitrothion flowable formulation - Sumithion 20 FL concentrate.

(c) Fenitrothion soluble formulation - Sumithion Technical (11%), Atlox 3409 F (1.5%), Dowanol (1.5%), Water 86%).

(d) Exposure of test organisms to toxicant for 96 hours was followed by exposure to clean water for 96 hours.

TABLE 2 FENITROTHION CONCENTRATIONS IN BLUE MUSSELS EXPOSED TO TWO CONCENTRATIONS OF FENITROTHION FLOWABLE

EXPOSURE TIME (days)	FENITROTHION CONCENTRATION IN TISSUES (ug/g wet weight)			
	TEST CONCENTRATION A (0.1 ug/L)		TEST CONCENTRATION B (0.6 ug/L)	
	NO DEPURATION	1 DAY DEPURATION	NO DEPURATION	1 DAY DEPURATION
3	1.67	0.11	12.50	0.47
1	1.85	0.93	13.66	0.74
2	2.29	0.02	10.41	0.29
4	1.56	0.01	17.68	0.91
10	1.66	0.09	17.02	0.72
30	1.54	0.03	21.73	0.37

the fenitrothion soluble product. Depuration was also very rapid with 80% of the accumulated pesticide being lost from tissues once the shellfish were placed in clean water.

These results would seem to indicate that the new fenitrothion flowable formulations pose approximately the same hazard to the aquatic organisms tested as do the older fenitrothion soluble formulations.

FIELD STUDIES - AQUATIC IMPACTS OF HIGH DOSE MEXACARBATE APPLICATIONS

A field project was conducted to determine the aquatic impacts of high dose mexacarbate applications aimed at spruce budmoth in the white spruce plantations of J.D. Irving in northern New Brunswick. Zectran UCZF-19, was applied by helicopter at a dosage rate of 150 g/ha, in a formulation of Zectran UCZF-19 (22%), Triton X-114 (3%) and water (75%) to a stream, from its source to the sampling point. The stream was located within an experiment spray block which was 200 ha in size. Measured parameters included pesticide concentrations in water, aquatic invertebrate drift, aquatic invertebrate colonization of artificial substrates, and brain acetylcholinesterase activity of captive brook trout (Salvelinus fontinalis).

Results available to date indicate a very low deposit of mexacarbate in the stream with the only detectable residues of approximately 0.10 ppb occurring between 5 and 45 minutes post-spray. The treatment stream was low in aquatic invertebrate abundance and diversity. The available invertebrate drift data indicate a reduction in numbers of three of the five Ephemeroptera taxa present in the samples. These include Ameletus spp., Epeorus spp. and Cinygmula subaequalis. There was also a reduction in these taxa on artificial substrates after spray. The artificial substrate data also indicate a reduction in total numbers of insects between 24 and 96 h after spray (Table 3). Numbers remained depressed until the final sample period 1 month after spray. Analysis of samples from the control stream continues.

TABLE 3 IDENTIFIED INVERTEBRATES IN ARTIFICIAL SUBSTRATES TAKEN FROM TREATED BROOK

TAXA			MEAN (± 1 S.D.) NUMBERS OF INVERTEBRATES (N=6)				
ORDER	FAMILY	GENUS SPECIES	1 DAY PRE	1 DAY POST	4 DAYS POST	8 DAYS POST	30 DAYS POST
Ephemeroptera	Siphlonuridae	Ameletus	0.7 ± 1.0	0.3 ± 0.8	0.3 ± 0.8	0	0
	Baetidae	Baetis	0.8 ± 0.7	0.3 ± 0.5	1.5 ± 1.5	0.2 ± 0.4	1.5 ± 1.5
	Heptageniidae	Epeorus	0.3 ± 0.5	2.2 ± 1.9	6.8 ± 1.0	0.5 ± 0.4	2.0 ± 2.2
		C. subaequalis	3.0 ± 1.7	1.8 ± 2.1	1.3 ± 1.0	0.3 ± 0.8	0.2 ± 0.4
	Ephemeridae	Ephemerella	0.3 ± 0.5	0.2 ± 0.4	0	0	0
Plecoptera	Nemouridae	Nemoura	1.2 ± 1.6	2.2 ± 2.7	1.3 ± 2.0	2.8 ± 3.8	2.8 ± 3.8
	Leuctridae	Leuctra	0.8 ± 0.4	1.5 ± 2.0	2.2 ± 1.5	0.2 ± 0.4	0.2 ± 0.4
	Chloroperlidae	Alloperla	0.7 ± 1.2	0.3 ± 0.5	0.3 ± 0.5	0	0
Trichoptera	Hydropsychidae	Aclopsyche	0.2 ± 0.4	0	0	0	0
	Limnephilidae	Limnephilus	0	0	0	0.2 ± 0.4	0.2 ± 0.4
Diptera	Simuliidae	Simulia vittatum	0	0.2 ± 0.4	0.8 ± 1.3	0	0
	Chironomidae		24.7 ±12.6	29.7 ±	25.7 ± 13.8	14.3 ± 6.7	11.2 ± 8.5

Fish brain acetylcholinesterase analyses are not complete at this time. However, it is worth noting that at 48 h after spray a number of the fish held in the treatment stream appeared sluggish and several had lost their righting response.

EFFECTS OF FOREST SPRAYING ON THE VERTEBRATE COMMUNITY OF BOG PONDS

W. L. Fairchild and D. C. Eidt

In 1985 the second year of study of the side effects of forest spraying in acidic (pH = 4.0) bog ponds was carried out. The treatment plan over the two years was:

Pond	1984	1985	
A	0	0	-control
B	0	T	-baseline then treated
C	T	0	-treated then recovery
D	T	T	-treated twice

0 = No spray T = Two fenitrothion sprays of 210g AI/ha spaced 5 to 7 days apart

An additional pond was treated each year with aminocarb (2 x 210g AI/ha). All sprays were applied from a boat with a Solo® backpack mistblower.

Pesticide residue analysis from 0.3m depth water samples in 1985 (XAD-4 resin and GLC; Vic Mallet, U. de Moncton) indicated peak concentrations of 49.5 and 42.2 ug/L 1/2 h after the initial spray. Concentration decreased to 5.9 and 8.3 ug/L 7 days later just prior to the second 1985 spray. Peak concentrations from the second spray were 18.8 and 24.3 ug/L at 24 h. Fenitrothion concentration after initial spray decayed rapidly from a sharp peak. Sampling after the second spray revealed no sharp peaks; the rise and fall in concentration was gradual. Three days after initial spraying concentrations fell below 10 ug/L whereas in the second spray 7 days elapsed before reaching 10 ug/L. Residues were 0.45 and 1.9 ug/L 3 weeks after spraying and reached nondetectable and 0.06 ug/L at 6 weeks.

Mean numbers for Gyrinidae (whirligig beetles) and for total organisms in extracted moss samples are now available. In the fenitrothion-treated ponds the Gyrinidae were eliminated in both 1984 and 1985. Recovery to near control levels took about 30 days. The gyrinid populations exceeded control levels by the end of the season. In 1985 the increase in treated ponds was accompanied by a decrease in control ponds (50 ind./quadrant, treated; >5, control; for 1985). This would indicate some interaction which makes treated ponds more attractive to gyrinids later in the season (removal of predators or competitors? increase in prey availability?).

Mean numbers of organisms extracted from moss samples were depressed after spraying and rose to or exceeded control numbers within 30 days. This rise was due in large part to a rapid increase in the nematode and annelid portion of the fauna. When nematodes and annelids were excluded from the mean the treated ponds showed deceases in the remaining fauna which lasted over winter from post spray 1984 until prespray 1985. Pond C, which was treated in 1984 and allowed to recover in 1985, did not show a return to control numbers until 15 months after it was sprayed. Analysis of these data and preparation of a more detailed set is currently underway.

Plans for 1986 include: (1) sampling to monitor recovery in all ponds, (2) an experiment on the notonectids and corixids, (3) further identification of faunal samples for preparation of a detailed data set.

MEXACARBATE-AQUATIC IMPACT STUDIES

S. B. Holmes

Studies on the environmental effects of mexacarbate (Zectran) when applied as a spruce budworm larvicide were conducted in Kent County, New Brunswick near the Trout Brook airstrip. A 500 ha block of forest surrounding the East Branch Little Forks Brook was sprayed twice with a water-based formulation of Zectran at a dosage rate of 70 g AI/ha. Brain acetylcholinesterase activity was measured in samples of native brook trout and Atlantic salmon collected by electro-seining as well as in hatchery-reared

brook trout held in cages in the treated stream. Benthic invertebrate populations and drift were monitored in the treated stream and in the West Branch Little Forks Brook which served as an untreated control. Aquatic invertebrate populations were also monitored in two small ponds, one inside and one outside the spray block. Green frog tadpoles were caged in the ponds to assess the acute toxicity of the insecticide at levels likely to be encountered in forest spray operations. Knockdown of arboreal and flying insects was measured using drop buckets placed under balsam fir trees along the treated and control streams. Results are not available at this time.

FIELD STUDIES - AQUATIC IMPACTS OF HEMLOCK LOOPER SPRAYS-NEWFOUNDLAND

W. Pierce

A study was undertaken by the Newfoundland District Office of EPS to determine if the fenitrothion treatments of the 1985 hemlock looper control program were having significant impacts on stream aquatic invertebrates. A previous study (Coady 1978) had indicated that Newfoundland stream biota were more severely impacted by fenitrothion sprays than studies from other jurisdictions would predict.

A treated and control stream were monitored after two operational sprays (direct overspray of streams) of fenitrothion (Folithion -11%, Cyclosol 63-40%, 585 diluent - 45%) at 210 g AI/ha. Parameters sampled included: water quality, stream flow, temperature, aquatic insect drift, aquatic insect colonization of artificial substrates and pesticide concentrations in water.

Maximum pesticide residue concentratin in water was 4 ppb 10 minutes after the first spray and 21 ppb 30 minutes after the second spray. Analysis of invertebrate samples collected is not complete at this point.

ECOLOGICAL IMPACTS OF NON PROTECTION

ECOLOGICAL IMPACTS OF THE BUDWORM-KILLED FOREST

P. Lane

Over the past century, the softwood forests of eastern Canada have experienced severe infestations of balsam fir by the spruce budworm, Choristoneura fumiferana. In the last decade, the forests of Cape Breton Island have sustained considerable damage from this insect. Forest managers have been divided on how best to control the insect damage and optimize multiple uses of the ecosystem. In particular, whether to employ chemical spraying or not has been a controversial issue. Nova Scotia was somewhat unusual in not allowing chemical control methods. The central question has been the following: is the risk-benefit ratio higher for the spraying or the unsprayed forest? Although the ecological risks associated with the sprayed forests are well documented, those related to the budworm-killed forest are not. This study attempts to synthesize existing information on ecological impacts in the budworm-killed forest with a central focus on Cape Breton Island. Thus, this study is preliminary to answering the central question. A variety of information sources were reviewed and organized into annotated bibliographies.

A set of maps is used to illustrate graphically how three biogeographical scales (Eastern North America, Atlantic Provinces and Cape Breton Island) are interrelated in regard to softwood defoliation and mortality. Both primary and secondary impacts associated with the budworm-killed forest are discussed under five general subjects: vegetation, soils and geology, water resources, fisheries, and wildlife. Many of the secondary impacts are associated with management practices such as harvesting, clear cutting, mechanical site preparation and replanting. The study concludes with the formulation of a two- phase research plan designed to supplement the current information base on ecological impacts reported here (Phase I). Phase II consists of a field study plan for the Cape Breton Highlands and a compilation of information on sprayed

and unsprayed forests. For Phase III, a risk-benefit comparison of sprayed versus nonsprayed forest is proposed. In addition, a related question requiring future research is outlined.

Major conclusions for each of the five subject areas for potential impacts are as follows: The immediate impact of the feeding of spruce budworm on a conifer forest is defoliation, loss of photosynthetic capability, cessation of growth, loss of productivity with more severe consequences occurring such as moribundity and mortality of trees. Defoliated trees are stressed and become increasingly susceptible to other insect pests, canopy and understory plants, and changes in successional patterns. Nutrient recycling, microclimate, and habitat structure are altered. In addition, management strategies all impact on the forest ecosystem. Changes in the forest, both budworm and human-induced, have consequences for soils, water resources, fisheries and wildlife.

It is likely that soil impacts are minor in budworm-killed forests which are not clear-cut. The flat topography, poor drainage, podzolic soils and peat bogs should mitigate large scale soil damage provided there is no disruption of the soil horizon. The most likely locations to observe possible soil impacts would be the steep slopes of the escarpment where there may be increases in infiltration rates, soil moisture, ion concentrations, bog area, and erosion.

There are no predictive models based on field data pertaining to the effects of spruce budworm-caused tree mortality on either surface or groundwater resources in eastern Canada or the United States. Impacts on the local water resources are likely to result from human interference with the succession of the forest. A review of available data for streams draining the Cape Breton Highlands indicates that they reflect conditions downstream of the Highlands Plateau, but not the Plateau itself. One study demonstrated, however, that degradation of water quality has occurred in Highland streams because of logging activities. An increasing volume of total runoff from the Highlands and increased sedimentation of some streams have been reported for the Northeastern Margaree River. It is not known how much of this impact is attributable to budworm

defoliation or to human activities such as the Wreck Cove hydroelectric development and clear cutting practices. Impacts on groundwater users in villages located along the base of the escarpment are likely to be minimal.

The impacts on fisheries are of a secondary nature and probably related mostly to management practices following softwood mortality. Changes in the terrestrial ecosystem in regard to the water cycle and mechanical movement of soil and biota translate into changes in stream flow, water quality, and spawning and feeding habitat quality, in neighbouring aquatic ecosystems.

There can be increased water temperatures from loss of shade, higher stream flows, more sedimentation, lower oxygen concentrations, more sediment barriers to fish emergence from the bottom and changes in available fish foods such as the diversity, abundance and productivity of benthic invertebrates. Most of these effects are negative, however, increased stream flow could be beneficial for environments normally subject to stressful low flow periods. Of the many possible changes in water chemistry, increased acidity, decreased pH and increased solubility of toxic metals such as aluminum compound acid precipitation impacts that are harmful to fish populations.

Among the mammals rated as rare, only the American marten has undoubtedly been severely impacted and the American red squirrel, has also certainly been negatively affected. Almost certainly, snowshoe hares and probably lynx, white-tailed deer, and moose have benefitted from clear cutting, although the balance between positive effects of browse release and negative effects of shelter destruction have not been given detailed study in the Highlands.

For the major pre-epidemic components of the Highlands avifauna, there are few quantitative data on relative or absolute abundances. Insectivorous species probably benefitted from, but obviously could not control, the budworm outbreak. It has been indicated in the Highlands, and demonstrated elsewhere, that abundances, although not diversities of bird species, are depressed in killed stands. The composition of the avifauna has been changed and even more so with subsequent clear cutting.

Within-habitat changes were probably more important than habitat fragmentation. Among rare bird species, only the boreal owl and three-toed woodpecker (these only hypothetically nesting) are candidates for negative impacts. Among gamebirds, only the scarce spruce grouse must have similarly suffered.

OTHER MONITORING PROGRAMS

ENVIRONMENTAL MONITORING IN NEWFOUNDLAND AND LABORADOR, 1985

S. Bonnyman

Spruce Budworm Environmental Monitoring Program

Environmental monitoring of the spruce budworm spraying program has been conducted annually in Newfoundland since 1977. Monitoring continued during years when no control program was necessary, in order to obtain a better baseline of data.

The 1985 monitoring program was consistent with a planned phase-down of monitoring activities for aminocarb. A final year of aquatic invertebrate work centered on use of artificial substrates. This represents the second and final year for the reversal of one set of control and sprayed streams. The 1984 results suggested some "rebounding" in the previously sprayed stream, which currently is not being treated. Some "depression" was evident in the original control, currently being treated. The results of the 1985 analysis are not yet available, but a preliminary report will be produced by March 31, 1986.

A two-year pollinator study to examine impacts of aminocarb began in 1985. The intended approach to use artificial domiciles proved successful for red ants but very unsuccessful for pollinators. An alternative program was developed using transects and observations of pollinator activity (number, species of pollinator, species of flower visited, weather, etc.). Results are currently unavailable. A second year of pollinator work is planned for the summer of 1986.

Hemlock Looper Environmental Monitoring Program

The Department of Forest Resources and Lands was required to conduct environmental monitoring associated with a control program for hemlock looper. Two studies were conducted, by contract, one

to examine impacts on pollinators, and second, to examine impacts on songbirds. A brief summary of these two reports follows.

Pollinators And Berry Production

Experimental blocks were located on the Avalon Peninsula. The original study was designed for aerial application during the blueberry flowering period, however, the operation program made this unrealistic. Instead, a late flowering species, raspberry, was selected as the target flowering species for pollinator activity. Visual spray plots were established, with pollinator activity observed for one minute, close to mid-day. Pollinators, and flowers were identified. Sweep net collections were made weekly. Fruit set was estimated by comparing the numbers of flowers and buds per stem to the number of ripening berries per stem.

This study was conducted to monitor the potential effect of fenitrothion spraying on pollinator activity and raspberry fruit set in the central Avalon Peninsula. Pollinator abundances in sweep net collections and activity on flowers were extremely variable due to a variety of factors. Data on fruit set were also inconclusive due to vandalism in the block that was sprayed and inadequate analysis (to be redone). Little speculation can therefore be made with regard to the effect of spraying on pollinators or berry production at this time.

Song Bird Study

A study was conducted to monitor the effect of fenitrothion spraying on several song-bird species in central Newfoundland through the depression of brain cholinesterase activity relative to unsprayed controls. From 29% - 100% of all birds collected from spray blocks had brain ChE activities depressed by more than 20% compared to average control values for those species, indicating probable exposure to a ChE inhibitor such as fenitrothion. No behavioural abnormalities were noted in the field, however, indicating that birds may not have been exposed to lethal levels of spray.

ENVIRONMENTAL MONITORING IN MAINE, 1985

S. Oliveri

Maine's Long Term Environmental Monitoring (LTEM) project continued for a third consecutive year in 1985. This study is designed to monitor chronic effects upon the forest ecosystem from spruce budworm suppression projects as well as uncontrolled budworm infestations. Aquatic invertebrates, fish, birds, tree condition, budworm and budworm parasitoids are monitored.

To date, no significant differences have been found in fish or invertebrate populations between streams with a history of insecticide spray activity nearby and those with no spray activity. It appears that populations of sensitive aquatic organisms, such as Plecoptera, have recovered from earlier impacts. This implies that Maine's spray buffer zones and use of insecticides less toxic to aquatic organisms have been successful mitigation measures. However, unsprayed stream borders that exhibit high levels of budworm induced tree mortality appear to have had an adverse impact on some streams. Increased water temperature, from loss of shade, and excessive numbers of dead trees that have fallen into the streams have degraded aquatic habitat. Invertebrate and fish populations in these streams have changed from cold water salmonid associations to those more characteristic of warmer, less oxygenated waters.

Bird populations have not been affected by past insecticide applications. Parasitoid populations appear to be more affected by budworm populations than by insecticide application. In many areas where budworm populations have declined, affected trees (both fir and spruce) are recovering.

In addition to the LTEM project, Maine has also been monitoring levels of microsporidial infection in budworm populations. Preliminary analyses indicate that there may be a relationship between currently declining budworm populations in Maine and microsporidian infection. This project will continue through 1986. The LTEM project however, will not be continued in 1986 due to lack of funding.

ENVIRONMENTAL MONITORING OF AERIAL SPRAYING OF INSECTICIDES AGAINST THE SPRUCE BUDWORM IN QUEBEC IN 1985

FATE OF *BACILLUS THURINGIENSIS* IN STREAMS WITHIN TREATED AREAS

S. Delisle, R. Dostie, and P.-M. Marotte

In 1985, the sixteenth year of the aerial spraying of insecticides against spruce budworm (*Choristoneura fumiferana*) Clem.), the Ministère de l'Energie et des Ressources of Quebec carried out a sampling program in order to evaluate the maximum concentrations and the persistance of viable spores of *Bacillus thuringiensis* (B.t.) in streams situated inside the treated areas. A total of 115 samples was taken during this program. Ninety samples were collected in areas treated by four-engine aircraft and twenty-five in areas treated by single-engine aircraft. The results of this study show that there was no trace of *B.t.* before the spraying operations in areas which have never been treated with biological insecticides. Moreover, maximum concentrations observed immediately after the application of insecticide ranged from 58.0 to 610.0 x 10^4 C.F.U./l in areas treated by four-engine aircraft, and from 140.0 to 860.0 x 10^4 C.F.U./l in areas treated by single-engine aircraft. These concentrations appeared between 20 and 120 minutes after spraying in areas treated by four-engine aircraft while in those treated by single-engine aircraft, the maximums were observed at 20 minutes. After a period of 11 to 50 days, concentrations ranging from 0.22 to 4.6 x 10^4 C.F.U./l were detected in the streams of the areas treated by four-engine aircraft. These concentrations represent less than 3% of the maximum concentration found in each stream.

RESIDUS DE FENITROTHION ET D'AMINOCARBE DANS L'EAU ET LE FEUILLAGE

R. Dostie, P-M. Marotte and G. Parent

En 1983, dans le cadre du programme du lutte contre la tordeuse des bourgeons de l'epinette (*Choristoneura fumiferana*, le Ministère de l'Energie

et des Ressources a procedé a la recolte d'échantillons d'eau et de feuillage. En milieu lotique, une heure après l'application, des residus maximum de 9,31 ug/l d'aminocarbe et de 5,94 ug/l de fénitrothion ont été détectés. En milieu lentique, les concentrations de fénitrothion et d'aminocarbe ont peu varie dans les deux nares echantillonnées durant des periodes respectives de six et 68 heures aprés l'application. Dans le feuillage de sapin baumier, des residus maximums de 14,1, de 13,6 et de 2,0 ug/g (poids sec) ont été détectés une a deux heures après l'application respectivemes pour le fénitrothion, le Matacil 180F et 180D. Toutes ces valeurs (eau et feuillage) sont comparables à celles detectées de 1979 à 1982.

Une analyse d'assiocation non-parametrique a été effectuée entre le feuillage du sapin baumier recolté en bordure des chemins forestiers et le depot enregistré au sol (aluminium et Kromekote MD). Des correlations significatives ont été obtenués entre le feuillage et les feuilles d'aluminium pour le fénitrothion et le Matacil 180F.

Avant les opérations 1983, des prélévements ont été effectués pour verifier la persistance des residus dans le feuillage traité antérieurement. Des concentrations de fénitrothion sont demeurées identiques à toutes les stations echantillonnées trois et cinq ans après une application experimentale. L'étude tend à demontrer que les residus de fénitrothion presents dans le feuillage une année aprés l'application sont stables et peuvent persister durant plusieurs années.

A l'intérieur d'une superficie traitée annuellement au fénitrothion, une valeur exceptionnelle de 6,34 ug/g a été détectée dans un échantillon prélevé dans le tiers supérieur des arbres 8 mois après les pulvérisations. A l'intérieur des peuplements semenciers, de nouvelles valeurs maximales ont été atteintes, soit 0,149 et 0,481 ug/g d'aminocarbe dans du feuillage traité en 1982 et récolté 11 mois après l'arrosage.

PERSISTENCE OF BIOLOGICAL INSECTICIDES IN THE FOREST AQUATIC ENVIRONMENT

J. Dugal, L. Major, P. Cardinal and S. Delisle

Within the environmental follow-up related to the fifteenth program of aerial spraying of insecticides to fight the spruce budworm (Choristoneura fumiferana), the ministère de l'Energie et des Ressources monitored the areas affected in order to study the fate and the persistence of Bacillus thuringiensis (B.t.) in the aquatic environment. A total of 237 water samples were taken in lotic (streams) and lentic (ponds) environments. The maximum concentrations of insecticides immediately after spraying were 500 x 104 and 3530 x 104 c.f.u./l respectively in these environments. The rate at which B.t. decreases differs considerably from one sampling station to another. Nevertheless, B.t. concentrations tended to decrease quickly right after spraying at all stations. In lentic environments,concentrations ranging between 135 and 3850 c.f.u./l were detected eleven months after spraying. In lotic environments, soil leaching may account for the presence of B.t. spores several months after spraying; concentrations ranging from 34 to 3289 c.f.u./l were detected.

The project regarding the persistence of B.t. in natural waters in the forest environment enabled us to observe that B.t. spores can persist in water despite Quebec's climatic variations. These residual concentrations proved to be less than 1% of maximum values.

EFFECTS OF FENITROTHION AND AMINOCARB ON FRUIT SET OF FOUR FOREST PLANT SPECIES.

R. Perreault

The fruit sets measured by the "fruit/flowers x 100" ratio were determined for Maianthemem canadense, Cornus canadensis, Clintonia borealis, and Aralia nudicaulis. The fecundity of C. borealis, expressed by the number of seeds/fruit, was also determined. These studies were carried out in the Quebec City, Rivière-du-Loup, Rimouski and Amqui areas. The ratios were compared in eight experimental

insecticide-sprayed areas and eight neighboring non-sprayed areas.

Study results show that fenitrothion and aminocarb spraying causes a fruit set reduction in M. canadense and C. canadensis. This decrease is no longer significant one year after the spraying.
The same conclusions can be made for the fecundity (expressed as the number of seeds/fruit) of C.borealis.

Insecticides also cause fruit sets to decrease in A.nudicaulis and C.borealis. Effects on these species may however extend beyond one year after spraying.

The repeated use of chemical insecticides causes a significant reduction in flower production in C. canadensis, and it seems that fenitrothion is the main element in this phenomenon.

It appears that fenitrothion and aminocarb sprays do not cause a decrease in the number of plants within treated areas. However, in order to confirm this observation and, more specifically, the absence of any long-term impact, a more detailed and better designed survey should be carried out.

Results do not allow one to distinguish the effects of repeated spraying of fenitrothion and those of aminocarb on the fruits sets of M.canadense, C.canadensis and C.borealis, nor on the seed production of the latter species. Decreased fruit set of A.nudicaulis does, however, seem to be related to the repeated use of fenitrothion.

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